

Distribution Pattern of *Emiliana huxleyi* Blooms in SeaWiFS Imagery

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Introduction

High concentrations or "blooms" of the coccolithophore *Emiliana huxleyi* (Fig. 1) significantly affect a region's ecology and chemistry. They act as a source of organic sulfur, i.e. dimethyl sulfide, to the atmosphere and CaCO_3 to the sediments, and alter the optical properties of the surface layer. Documenting the presence of their blooms, both in time and space, is consequently essential in characterizing the biological and geochemical environment of a region. Their distribution pattern may also be used to define the environmental conditions favorable for their initiation and growth.

E. huxleyi blooms occupying the surface layer are detectable in visible satellite imagery owing to their high ocean volume reflectance. In Coastal Zone Color Scanner (CZCS) imagery, their blooms were detected in several

locations using supervised, multispectral classification. Large expanses possessing the spectral signature of *E. huxleyi* blooms were found in waters of the subpolar North Atlantic and North Pacific, and along the Argentine shelf break from summer to early autumn. Unfortunately, image coverage was poor during the CZCS mission, varying both temporally and spatially.



Figure 1. Scanning electron photomicrograph of the coccolithophore *Emiliana huxleyi*.

The objective of this study is to improve our understanding of the global distribution pattern of *E. huxleyi* blooms established using CZCS imagery. As a preliminary step towards this objective, the presence of *E. huxleyi* blooms was mapped in Sea-viewing Wide Field-of-view (SeaWiFS) imagery.

Approach

The distribution pattern of *E. huxleyi* blooms in surface waters of the world's oceans was mapped by classifying pixels of weekly (8 - day) composites of SeaWiFS imagery from September 1997 to August 1999 into coccolithophore and non-coccolithophore classes using a supervised, multispectral algorithm. The classification algorithm, based upon mean normalized water-leaving radiances ($nL_{w,\lambda}$, where $\lambda = 443, 510, \text{ and } 555 \text{ nm}$), was a modified version of the program developed by Brown and Yoder (1994) to detect *E. huxleyi* blooms in CZCS imagery. Modifications were based upon the spectral signatures of blooms located in the Bering Sea (April 25, 1998), the Celtic Sea (May 18, 1998), and the central N. Atlantic (June 15, 1998). A bathymetric threshold ($> 100 \text{ meters}$) was also implemented between 45°S and 45°N to reduce the identification of shallow carbonate shelves as *E. huxleyi* blooms.

Seasonal, annual, and mission composites were produced by combining sequential classified images in such a way as to display the location of all classified blooms detected during the specified period.

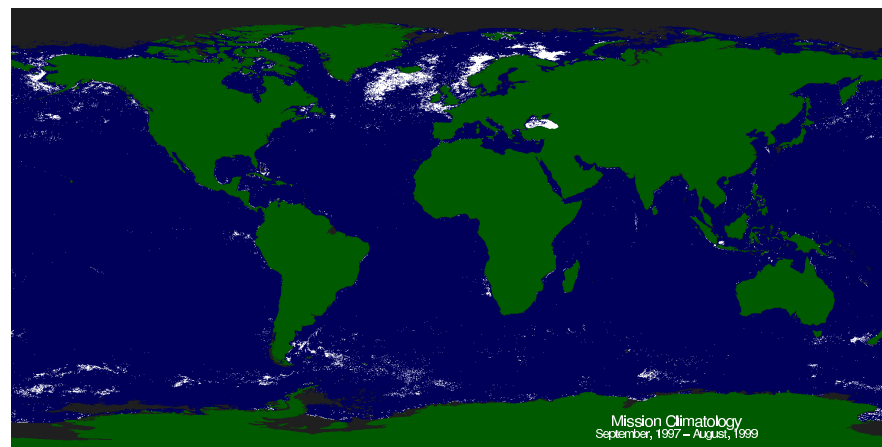
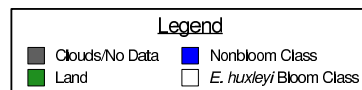


Figure 2. Mission climatology of classified *E. huxleyi* blooms. Composite period: September, 1997 – August, 1999.

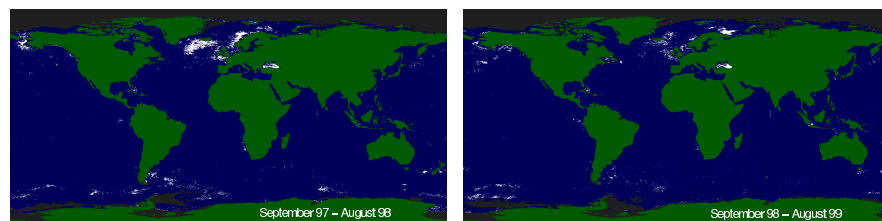


Figure 3. Annual composites of classified *E. huxleyi* blooms. Composite period: September, 1997 – August, 1999.

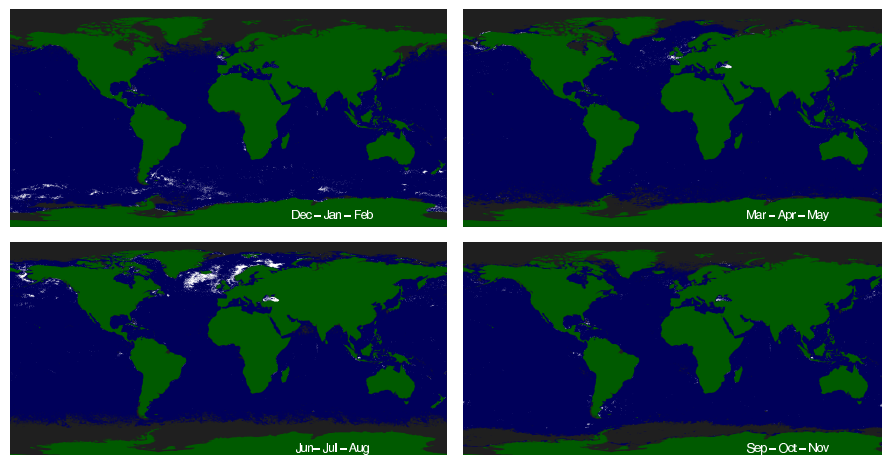


Figure 4. Seasonal composites of classified *E. huxleyi* blooms. Composite period: September, 1997 – August, 1999.

Results

The distribution pattern of classified *E. huxleyi* blooms detected in SeaWiFS imagery is illustrated in the mission (Fig. 2), annual (Fig. 3), and seasonal (Fig. 4) composites. Classified blooms were found typically in the subpolar latitudes during the summer months, with the largest expanse in the North Atlantic. They were also observed in the Bering Sea, Norwegian Sea, the Southern Ocean, and the waters off Chile, Namibia, New Zealand, and the Galapagos Islands. In the Black Sea, the bloom signal was observed from spring to fall. Classified blooms were uncommon or absent in the Persian Gulf, and Indonesian waters during the entire period examined and in the western North Atlantic in 1997 – 1998. The areal extent of classified blooms was greater during the first year of SeaWiFS (09/97–08/99: 888,000) than the second (09/98–08/99: 631,000 km²).

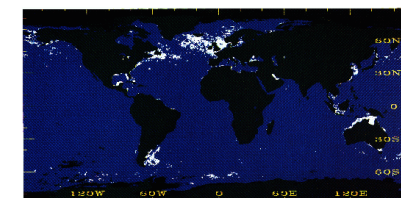


Figure 5. CZCS mission climatology of classified *E. huxleyi* blooms. Composite period: November, 1978 – April, 1986.

Discussion

In general, the global pattern of classified *E. huxleyi* blooms derived from SeaWiFS (Fig. 2) and CZCS (Fig. 5) imagery are similar. Large expanses of classified blooms were found in the subpolar latitudes during the summer months, particularly in the central North Atlantic. Differences, however, exist.

The decrease of classified blooms in the Persian Gulf and Indonesian seas represent a beneficial consequence of applying the bathymetric threshold. These regions, not known to harbor *E. huxleyi* blooms, were categorized as blooms in CZCS imagery because they typically possess shallow ($< 100 \text{ m}$), calcareous sediments. The conspicuous absence of classified blooms in the western North Atlantic in 1997 – 1998 (Fig. 3) suggests a change in ecosystem structure of this region because *E. huxleyi* blooms represent a well documented and frequent event in this area during the CZCS era to the early 1990's. Imagery from 1998 – 1999, however, indicates blooms were once again present in the Gulf of Maine and Gulf of St. Lawrence this past summer.

The presence of classified *E. huxleyi* blooms in the Bering Sea agrees with documented accounts of their existence during the SeaWiFS era, in contrast to their unconfirmed (and unlikely) occurrence during CZCS. Their appearance in the vicinity of the Antarctic Polar Front in the Southern Ocean, similar to that observed in CZCS imagery, is intriguing and biogeochemically significant, yet requires verification.

Literature Cited
Brown, C. W., and Yoder, J. A. (1994). Coccolithophore blooms in the global ocean. *J. Geophys. Res.* 99:7467–7482.

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